National Action Plan on Breast Cancer Etiology Working Group: Workshop on Physical Activity and Breast Cancer

Supplement to ***Cancer***

Physical Activity and Breast Cancer

Evaluation of Physical Activity Assessment Methods

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Presented at the National Action Plan on Breast Cancer's Workshop on Physical Activity and Breast Cancer, Albuquerque, New Mexico, November 13-14, 1997.

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Received April 24, 1998; accepted May 15, 1998.

Studies of the association between physical activity and breast cancer have yielded inconsistent findings. These findings may be related to a true null association or an inability to measure physical activity with enough precision to measure a protective relation. The authors reviewed and critiqued physical activity measurement methods used in published studies of the association between physical activity and breast cancer. The authors examined the quality of physical activity measures in 20 published studies. A summary score was created to rank the quality of the activity score. Studies with higher scores had a more precise measure of physical activity. Physical activity measurement methods were different in each study. Activity was measured by job classification, occupational tasks, participation in competitive athletics, and recreational and leisure-time pursuits. The recall period for physical activity ranged from a lifetime to the past year. Comparison of quality scores showed no associations between the precision of activity measures and the study results. Future studies of physical activity and breast cancer should utilize standardized methods to measure physical activity. Researchers should be encouraged to choose a measure based on hypotheses regarding physical activity and breast cancer mechanisms. Studies also should extend to subgroups of women with differences in other breast cancer risk factors, such as body mass, menopausal status, and hormone replacement status. ***Cancer*** **1998;83:611–20.**

KEYWORDS: physical activity, breast cancer, questionnaires, women, exercise.

As with other complex behaviors, an accurate measurement of lifetime patterns of physical activity is difficult to achieve. Few people have stable physical activity patterns throughout their lifetime. Instead, most people have physical activity patterns that vary daily, seasonally, or during different periods of their life. When trying to determine whether physical activity is related to the risk for different diseases, several questions arise. What are the periods of life when activity levels are highest and/or lowest? Is there a critical period in one's life when physical activity may modify mechanisms related to developing a disease? If one engages in regular physical activity, is there an optimal intensity, duration, or frequency of activity that modifies disease risk? Is it possible to measure physical activity with sufficient accuracy to detect associations between physical activity and the risks for disease? Answers to these questions may differ for different diseases.

There are several difficulties when attempting to establish an association between physical activity and protection from breast cancer. First is the choice of which measure of physical activity to use. There are many direct and indirect ways to measure physical activity;

TABLE 1
Physical Activity Assessment Methods[42,43]

Direct	**Examples**
Concurrent recordings	Physical records and logs, audiotape recordings
Motion detectors	Accelerometers, pedometers, electronic and mechanical motion sensors
Observation	In-person observation, videotape recordings
Direct calorimetry	Insulated chamber or space suit
Doubly isotopically labeled water	
Indirect	**Examples**
Metabolic measures	Hormones, lipids and lipoproteins, enzymes, substrate oxidation characteristics, glucose tolerance, insulin sensitivity
Morphologic measures	Body mass for height, body composition, subcutaneous fat distribution, abdominal visceral fat, bone density, flexibility
Cardiorespiratory measures	Maximal aerobic power, submaximal exercise capacity, heart functions, lung functions, blood pressure
Motor measures	Static and dynamic balance, agility, coordination, speed of movement
Muscular measures	Isometric and isotonic strength, power, muscular endurance
Health status	Life-style behaviors, physical and social environment, health history
Surveys	Global, recall, quantitative history

however, each method has its strengths and weaknesses. No single method is accurate enough to be called a "gold standard." Second, women's physical activity patterns are poorly understood. Activity levels can vary depending on family care, home, and job responsibilities. This can make generalizations regarding women's activity patterns very difficult. Third, we know very little regarding how physical activity modifies the various mechanisms associated with the development of breast cancer or during what period of life the effect of physical activity is most influential. The purpose of this article was to discuss physical activity measurement issues related to identifying protective associations between physical activity and breast cancer.

Measuring Physical Activity

Physical activity is defined as any bodily movement produced by skeletal muscles that results in energy expenditure.[1] Methods used to measure physical activity are classified as direct and indirect (Table 1).[2] Direct methods include a concurrent assessment of physical activity. This may include measuring the release of body heat during activity in a calorimetry chamber; directly observing someone's movement to classify it on a rating scale; recording movement with a video camera for later classification; recording patterns of movement using accelerometers, pedometers, or other motion detectors; recording physiologic changes (such as in the heart rate) that occur with movement; or by having people keep physical activity records and/or logs of their physical activity patterns. Direct methods tend to be extremely precise, but assess current energy expenditure only. They are expensive to apply with large numbers of subjects, which is typical in the majority of epidemiologic studies. Indirect methods of physical activity assessment, such as physiologic measures and surveys, provide a surrogate measure of activity status. Physiologic measures that are modified by different levels of physical activity are cardiorespiratory fitness, percent body fat, measures of regional adiposity, insulin, glucose, lipids, selected hormones, and factors related to the immune response. Physiologic measures may reflect current activity or, in some instances, provide an indication of activity over time.

Surveys commonly are used to measure physical activity in epidemiologic studies. One of the strengths of surveys is that they are inexpensive, do not have a large participant burden, and can be used to identify different types of activity performed in different life periods. However, a weakness of all surveys is potential recall bias and an inability to recall activities or account for all types of activity performed on a daily basis. It is difficult to precisely recall activity habits, especially those that are done as part of the usual living routine. We also know very little regarding cognitive factors related to the recall of physical activity.[3] For example, does recall of activity patterns vary by disease status or by levels of activity?

Physical activity surveys are comprised of three types: global, recall, and quantitative history. Global surveys are short, comprised of one to four items. Global surveys provide a general impression of one's physical activity status. Physical activity measures are expressed as categoric scores indicating higher or lower activity status. Global surveys published in the literature provide a good surrogate measure of participation in vigorous physical activities.[4] Recall surveys have questions regarding physical activity performed in the past week or 2 weeks. Physical activity scores are expressed as ordinal scales, such as kilocalories expended per day or per week in all activities or in selected activity types, or as other types of activity units that may reflect the time spent in different intensity levels (MET-hours per day). Correlations between recall surveys and actual physical activity participation habits vary. Activities that are easier to recall, such as vigorous activities or special planned activities, correlate well with direct measures of such activities.[5] However, activities performed at light and moderate levels of intensity, or activities performed daily, correlate less well with direct measures of physical activity.[4,5] Quantitative history physical activity surveys may have items that identify the intensity, frequency, and duration of many activities performed in the past several months, year(s), or over the course of the individual's lifetime. Physical activity scores are expressed as average kilocalories per day or MET-hours per day. Although quantitative history surveys take longer to administer (approximately $\geq$ 0.5 hours), they can account for seasonal or lifetime changes in physical activity. Correlations between quantitative history surveys and direct measures of physical activity are modest (correlation coefficient range, 0.23–0.40).[4]

On surveys, physical activities often are categorized by type and intensity. Participation habits are measured as the frequency and duration of activity. Types of activity measured on physical activity surveys include occupational, recreational, leisure, family care, household, and various other types of physical activity. The intensity of physical activity represents the metabolic effort required to perform the activity. Intensity is often measured in MET units. A MET is the ratio of the activity metabolic rate to the resting metabolic rate. Recommended cutpoints for classification of intensity levels are: light (less than three METs), moderate (three to six METs), and vigorous (greater than six METs).[6] However, these cutpoints may vary among studies.[4] The duration of an activity refers to the minutes or hours one performs each activity session. The frequency reflects the activity sessions performed per day, week, or month. Multiplication of the intensity, duration, and frequency terms reflect the volume or dose of activity obtained during a session or series of sessions. The volume or dose of activity can be expressed as kilocalories or MET-hours per session, day, week, or month.

Physical Activity Measurement in Epidemiologic Breast Cancer Studies

In the 20 studies of physical activity and breast cancer published to date, physical activity has been measured either by job classification,[7–11] categorization by participation in college athletics,[12,13] or survey procedures regarding recreational activity[13–21] or both recreational and occupational (or nonrecreational) activity, either separately[22–25] or combined.[26] Among the five studies relying on job classification, three different approaches have been used: 1) a five-level ranking based on Department of Labor activity requirements for occupational census codes[9,10]; 2) two three-level rankings based on amount of sitting time and energy expenditure required for different occupational categories[7,8]; and 3) categorization of teachers based on subject (physical education vs. language teachers).[11,27] Survey procedures have included global ratings of activity level,[19,25,26] general or recall surveys,[18,21–24] and quantitative activity histories.[13–17,20] An identical survey procedure has been used only twice.[16,17] The summary activity measures have been expressed in units ranging from a dichotomous yes/no (e.g., college athlete, not college athlete)[12,13,27] to a simple ordinal ranking[7–10,19,22,24–26] to hours per week,[14–17,21] frequency per week or year,[16,17,20] kilocalories per week,[13,15,18] or mean or total energy expenditure.[16,17,20] The time frame for which activity was assessed also has varied. Lifetime[7] and usual occupational activity[9,10,27] as well as occupational activity at the time of diagnosis,[8] at ages 15–10 years, 30–39 years, and 50–59 years,[22] and at the time of entry into the cohort[23,24] all have been considered. For recreational activity, the time frame has included teenage years,[14–17,20–22] college years,[12] adult premenopausal ages,[15,21,22] middle age,[22] the year or two prior to breast cancer diagnosis or index date,[16–19] lifetime,[14] and time of entry into cohort.[13,24–26]

To examine the extent to which differences in the quality of the activity measures influence the results of these studies and contribute to inconsistencies, we applied the criteria put forth by Powell et al.[29] for evaluating activity measures used in studies of activity and coronary heart disease. Briefly, those criteria are: 1) clearly stated operational definition of activity; 2) accuracy defined by demonstrated reliability and validity of measure; 3) measurement of exposure at the level of the individual and not presumed based on group membership; 4) measurement of dose, including frequency, duration, and intensity; 5) measurement of lifetime exposure; 6) repeated measure of exposure to ensure consistency of classification (particularly relevant in cohort studies); and 7) standardized method of measurement for each individual in the sample. As shown in Table 2, studies were given two plus symbols for each criterion that was fully met, one plus symbol if met in part, and a minus symbol if no criteria were met or if uncertain. An overall score was given by adding the total number of plus symbols. To provide as much of a visual overview as possible of

TABLE 2
Quality of Activity Measures in Studies of Physical Activity and Breast Cancer

			Quality of measure[a]								
Reference	Activity measure	Time frame	Op def	Accur	Indiv	Dose	Life	Rept	St Coll	Score[b]	Results[c]
Case–control studies											
Dosemeci et al., 1993 Turkey[7]	Job classification, three-level ranking based on time sitting and energy expenditure for coded job title	Lifetime	++	−	−	−	+	−	++	5	−
Zheng et al., 1993[8] China	Job classification, same as Dosemeci et al.[7]	Time of diagnosis	++	−	−	−	+	−	++	5	++
Coogan et al., 1997[9] U.S.	Job classification, five-level ranking based on physical requirements for coded job title	Usual	++	−	−	−	+	−	++	5	+
Bernstein et al., 1994[14] U.S.	Qunatitative, recreational activity survey, expressed as average kcal/wk Global questions, three-level ranking of frequency of exercise for health	Lifetime, 10 yrs after menarche	++	+	++	+	++	−	++	10	++
Friedenreich and Rohan, 1994,[18] Australia	General recreational activity survey, expressed as average hrs/wk	Year prior to diagnosis	++	+	++	+	−	−	++	8	+
Hirose et al.,[19] U.S.	Global questions, three-level ranking of frequency of exercise for health	Prior to diagnosis	+	−	++	−	−	−	++	5	++
Mittendorf et al., 1995[20] U.S.	Quantitative strenuous recreational activity survey, expressed as kcal/wk and hrs/wk	Ages 14–18 yrs and 18–22 yrs	+	−	++	+	+	−	++	7	++
Taioli et al., 1995[15] U.S.	Quantitative recreational activity survey, expressed as kcal/wk and hrs/wk	Ages 15–21 yrs, 22–44 yrs, and 45+ yrs	+	+	++	+	+	−	++	8	−
McTiernan et al., 1996[16] U.S.	Quantitative recreational activity survey, expressed as total METs, frequency/wk, and hrs/wk	Two yrs prior to diagnosis, Ages 12–21 yrs	++	+	++	++	+	−	++	10	+
Chen et al., 1997[17] U.S.	Quantitative recreational activity survey, same as McTiernan et al.[16]	Two yrs prior to diagnosis, ages 12–21 yrs	++	+	++	++	+	−	++	10	−
Hu et al., 1997[21] Japan	General recreational activity survey, expressed as kcal/wk	Teenage yrs, 20's	++	−	++	+	+	−	++	8	−
D'Avanzo et al., 1996[22] Italy	General survey regarding occupational activity, expressed as five-level categoric ranking of hrs/wk	Ages 15–19 yrs, 30–39 yrs, and 50–59 yrs	++	−	++	+	++	−	++	9	++[d] +[e]
Record linkage, retrospective cohort											
Vena et al., 1987[10] U.S.	Job classification, same as Coogan et al.[9]	Usual	++	−	−	−	+	−	++	5	++
Pukkala et al., 1993[11] and Vihko et al., 1992[27]	Job classification, expressed as physical education or language teacher	At entry into profession	++	+	−	−	−	−	++	5	−

(continued)

TABLE 2. (continued)

Reference	Activity measure	Time frame	Quality of measure[a] Op def	Accur	Indiv	Dose	Life	Rept	St Coll	Score[b]	Results[c]
Frisch et al., 1987[12] U.S.	Participation in college athletics	College years	++	+	−	−	−	−	++	5	+
Prospective cohorts											
Paffenbarger et al., 1992[13] U.S.	Participation in college athletics, quantitative activity survey of sports, exercise, walking and stairs, expressed as kcal/wk	College years and entry into cohort	++	++	++	++	−	−	++	10	−
Dorgan et al., 1993[23] U.S.	General recreational and occupational survey, expressed as an activity index and intensity specific and domain specific hrs/day	Entry into cohort	++	+	++	+	−	−	++	8	−
Thune et al., 1997[24] Norway	General survey of occupational and recreational activity, each expressed as four-level ranking	Entry into cohort	++	−	++	+	−	+	++	8	++
Garfinkel, 1988[26] U.S.	General survey of occupational and recreational activity, each expressed as a four-level self-ranking	Baseline	++	−	++	−	−	−	−	6	−
Albanes et al., 1989[25] U.S.	Global questions, three-level self-ranking of recreational and nonrecreational activity	Baseline	++	−	++	−	−	−	−	6	−

Op def: operational definition of activity; Accur: accuracy; Indiv: measurement of exposure at the level of the individual; dose: dose including frequency, duration, and intensity; Life: lifetime exposure; Rept: repeated measure of exposure; St. Coll: standardized method of collection; kcal: kilocalorie; MET: ratio of activity metabolic rate to resting metabolic rate.

[a] ++: yes; +: in part; −: no or uncertain.

[b] Score is total number of plus symbols.

[c] ++: protective relation; +: suggestive of a protective relation; −: no relation.

[d] Result for occupational activity.

[e] Result for recreational activity.

the various methods utilized in these studies, Table 2 is organized first by study design and then, within each study design stratum, by type of activity measured (occupational, recreational, or both) and in descending date of publication. Also shown in Table 2 is a column indicating the study findings, with two plus symbols for a definitive inverse relation between activity and breast cancer, one plus symbol for a suggestive inverse relation, and a minus symbol for no inverse relation.

To fully meet the criterion of clear operational definition, a clear and replicable explanation had to be provided of how the summary measure was derived from the collected data. As Table 2 indicates, all but three of the studies fully met this criterion. In contrast, only one study was given two plus symbols for using an activity measure with established reliability and validity. Although many of the other studies used measures for which data exist regarding their accuracy, they were applied to time frames far in the past. Because little is known regarding the accuracy of distant recall of physical activity, particularly of specific details such as frequency or duration, those studies were given only one plus symbol. Studies either did not meet or fully met the criterion of measuring activity on the level of the individual rather than presuming activity level based on group membership. Only those relying on job title or records of participation in college athletics failed to meet this criterion. To receive two plus symbols for the criterion of dose, data on intensity, frequency, and duration had to be collected. Only three studies fully met this requirement. However, all the studies that used either a general or quantitative activity survey had data on at least one of these variables (and usually two) and therefore were given one plus symbol. Although many studies attempted to capture activity at different times of life and were given one plus symbol for the lifetime criterion, only

TABLE 3
Frequency of Breast Cancer and Physical Activity Study Findings[a] by Overall Quality[b] of Activity Measurement

	Study findings		
Quality	++	+	−
5	4	1	2
6	0	0	2
7	1	0	0
8	1	1	3
9	1	1	0
10	1	1	2
Total[c]	8	4	9

[a] ++: inverse relation; +: suggestive inverse relation; −: no inverse relation.
[b] Quality score is the number of pluses given for seven criteria specified for evaluation activity measure.
[c] One study had a score of 9 with ++ finding for occupational activity and + finding for recreational activity.

two studies fully covered the life span from puberty onward and were given two plus symbols. Repeated measurement of activity is a criterion applicable only to cohort studies and was met, in part, only by one study. However, all the studies fully met the criterion of standardized data collection.

For the case-control studies, the maximum overall score was 12 with the actual scores ranging from 5–10. The cohort studies had the same range of scores even though the maximum score possible was 14. Table 3, which shows the frequency of different study results (inverse relation, suggestive inverse relation, and no inverse relation) by overall score, suggests little relation between the quality of the activity measure and the study results. Although one of the four studies with the highest score[10] found a clear protective relation between activity and breast cancer and another found a suggestive relation, two studies found no relation. Furthermore, there is little tendency for the number of studies finding a protective relation to increase as the quality of the measure increases. In addition, the distribution of study findings among the studies using activity measures with lower overall quality is similar to the distribution of findings in studies with higher quality measures. The implication of this frequency distribution is that the inconsistent results of studies of activity and breast cancer are not primarily due to differences in activity measurement.

However, there are other methodologic differences that may, by themselves or in combination with different methods of activity assessment, contribute to the lack of consistency. For example considerations of sample size is important. The number of breast cancer cases in these studies ranged from a low of fewer than 5[26] to a high of 6888,[20] with 3 studies having fewer than 100 cases,[12,13,26] 11 having between 100 and 1000 cases,[7,10,14–18,21,23–25,27] and 5 having $>$ 1000 cases.[8,9,19,20,22] Because one study with a high quality measure of activity had a small number of cases,[13] the absence of a relation may be due to insufficient statistical power to detect a true relation that may exist.

In addition to published studies, there are at least 20 ongoing studies that assess the relation between physical activity and breast cancer (Table 4). The study designs mostly are case-control and prospective cohort studies, but include one clinical trial. All the surveys used to measure the association between physical activity and breast cancer include questions regarding recreational activities. Seven studies contain questions regarding household activities and six contain questions regarding occupational physical activities. Only six of the study surveys measure recreational, occupational, and household physical activity. Although a detailed evaluation of all physical activity surveys now being used to measure the relation between physical activity and breast cancer was not conducted, it appears that the range of quality of the surveys now being used in ongoing studies are similar to those reported in Table 2.

We do not conclude from the analysis of study results and the quality of activity measurements presented in this article that the quality of activity measurement is unimportant. Quite the opposite is true. The variability of findings among those studies with high quality measurements suggests the possibility that there is no strong relation between physical activity and breast cancer. Only more studies using high quality activity assessment and generally strong overall methodologic approaches will be able to provide a definitive answer to the true nature of this relation.

Measuring Physical Activity in Future Studies

Prevalence estimates of physical activity levels suggest that nearly 65% of women in the U.S. do not obtain sufficient amounts of physical activity to reduce their risks for chronic diseases. According to data obtained in the 1992 Behavioral Risk Factor Surveillance System Survey, nearly 31% of adult women age $\geq$ 18 years report no participation in leisure-time physical activity. Another 34% of adult women participate in physical activity with insufficient frequency, intensity, or duration to modify their disease risks.[30] The lower levels of physical activity among women reported in national surveys may reflect true inactive lifestyles, or they may be related to measuring inappropriate activities. Women often are more involved in unstructured physical activities due to their multiple responsibilities at work, with their family, and in the community.[31] Also, women may not engage in regular organized sports or conditioning activities due to a lack of op-

TABLE 4
Ongoing Studies of Physical Activity and Breast Cancer

Principal group or investigator	Location or group being studied	Time of study	Method of data collection	Type of activity measured
Population-based, case–control studies				
Bernstein et al.	Women's care study	1994–1998	Interview	Recreational
Britton et al.	Women's Interview Study of Health	1990–1992	Interview	Recreational
Dorn et al.	Western New York State	1986–1991	Interview	Recreational Occupational
Friedenreich et al.	Alberta	1995–1998	Interview	Recreational Occupational Household
Gililand et al.	New Mexico	1992–1993	Interview	Recreational Occupational Household
John et al.	California	1995–1998	Interview	Recreational Occupational Household
Johnson et al.	Canada	1994–1996	Self-administered interview	Recreational
Newcomb et al.	Mass & NH	1997–2001	Self-administered interview	Recreational Occupational
Zheng et al.	Shanghai	1996–2000	Interview	Recreational Occupational Household
Prospective cohort				
American Cancer Society	U.S.	1992–1993	Self-administered	Recreational
		1997–1998		Occupational Household
Bernstein et al.	California teachers	1995–indeterminant	Self-administered	Recreational
Kolonel et al.	Hawaii and Los Angeles	1993–1996	Self-administered	Recreational
Moradi et al.	Sweden	1960–1989	Census	Occupational
Riboli et al.	European Prospective investigation into cancer and Nutrition	1993–indeterminant	Self-administered	Recreational Occupational Household
Rosenberg et al.	Black Women's Health Study	1995–indeterminant	Self-administered	Recreational Occupational Household
Speizer et al.	Nurses Health Study I	1976–indeterminant	Self-administered	Recreational
Willett et al.	Nurses Health Study II	1989–indeterminant	Self-administered	Recreational

Mass: Massachusetts; NH: New Hampshire.

portunity or perceptions regarding the appropriateness of such activities.[31]

Our ability to detect and interpret associations between physical activity and breast cancer is dependent on our ability to measure effectively the relevant components of physical activity. Past studies of physical activity and evaluation of potential mechanisms whereby physical activity may be associated with breast cancer indicate that several dimensions of activity may be important in studies of breast cancer.

In their article, Hoffman-Goetz and Husted[32] hypothesize that regular physical activity may reduce the risk of breast cancer by altering the effects of growth hormones and sex steroids as breast cancer promoters, influencing the immune system, and/or modifying energy balance to reduce total and regional body fat. To examine how physical activity relates to these hypothesized mechanisms, controlled activity trials in a laboratory setting are needed. Physical activity should be measured using motor-driven treadmills or cycle ergometers that permit an objective evaluation of work performed. Evaluation of physiologic mechanisms in trained and untrained women can show the effects of chronic exercise on breast cancer risks. The effects of activity on the hypothesized mechanisms can be observed after acute bouts of activity (after a single session) or after a predetermined volume of accumulated activity. Laboratory settings also are useful to conduct controlled training studies to identify the impact of exercise frequency, intensity, and duration on mechanisms associated with breast cancer risk.

Because activities performed at a vigorous levels of intensity may be associated with hormone production and uptake, immune function, and/or prostaglandin production and uptake, and overall energy expenditure may be important to maintain body weight and energy balance, levels both of intensity and total activity need to be ascertained in future studies of physical activity and breast cancer. However, validation of physical activity recall surveys needs to be correlated with mechanisms that may be associated with breast cancer. For instance, although many existing physical activity questionnaires have been compared with results from treadmill tests,[5,33] we do not know how measures of physical activity obtained from these questionnaires correlate with hormone levels, the distribution of body fat, immune function, and prostaglandin production. Tools determined to be sensitive to the mechanisms of interest will further our understanding of the relation between physical activity and breast cancer and provide support for observed associations.

Physical activities also should reflect the types of activities done by women in the survey population and reflect their cultural interests. Failure to include activities that are specific to populations surveyed and that are known to modify mechanisms associated with physical activity and breast cancer may lead a researcher to accept the null hypothesis when a true relation exists.

Cultural differences can affect the correlation between a component of physical activity such as occupation to total activity. In many developing countries, the nonoccupational activity is so great (e.g., walking or biking 2 hours per day to commute to work) that occupational activity is a poor indicator of total activity. Another important issue in determining an association between physical activity and breast cancer is the ability to measure historic patterns of physical activity among women. In 1987, Frisch et al.[12] hypothesized that strenuous physical activity during adolescence may alter the risk for breast cancer by delaying or interrupting the menstrual cycle and circulating estrogen levels. Since then, breast cancer researchers have been interested in measuring physical activity across the life span.[13–17,22] Although it is difficult to validate responses to historic surveys using direct and indirect measures of physical activity, some studies suggest that ability to recall historic physical activity is reasonably good.[28,34–37] Studies of other cancers have shown that long term activity patterns may be more predictive of associations than activity patterns for one point in time.[38,39] This could be the result of a more accurate identification of the truly active when people are asked to report activity patterns over time. Conversely, it is possible that obtaining long term activity patterns enable the detection of a relevant time when physical activity may be significantly related to the development of cancer. Additional studies are needed to develop reliable and valid measures of historic activity. For example, training logs or school activity records may be useful items with which to validate the recall of past athletic participation.

Studies examining physical activity and breast cancer need to go beyond the evaluation of the independent association between the two. Because physical activity is one component of life-style style patterns, it is important to examine differences in associations between physical activity and breast cancer in subgroups of the population. These subgroups include women who are younger and older at the time of diagnosis with breast cancer; women who are pre- and postmenopausal; women who use and do not use hormone replacement therapy; women who have high and low energy intakes; and women who have different ranges of body size. Differences in underlying characteristics of the population may be critical to our ability to evaluate accurately the associations between physical activity and breast cancer and appreciate differences in associations that may be observed between populations.

Future studies of physical activity and breast cancer need to be conducted in such a manner as to be able to provide a solid message as to the type, amount, and frequency of physical activity most beneficial. In the Surgeon General's Report on Physical Activity and Health,[11] it is clear that multiple messages exist. Studies must be able to determine which messages are most important for women at risk of breast cancer and therefore must measure the frequency, duration, and intensity of activities performed in such a manner that they can be used to provide a sound public health message.

Current challenges facing physical activity and cancer researchers include identifying valid and reliable ways to measure physical activity among women and ways to measure physical activity across the life span. Thus, we need to identify the types of physical activity women perform on a regular basis that may modify their risks for breast cancer,[40] standardize physical activity measurement methods among researchers,[41] apply strategies to help women recall physical activity from the past,[3,28] and interpret findings in such a manner that they can be incorporated into women's life-styles.

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